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European House Cricket (Acheta domesticus) Behavorial Decision Making and Resource Prioritization

European House Cricket (*Acheta domesticus*) Behavorial Decision-Making and Resource Prioritization

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Abstract

This study investigates the olfactory decision-making of the *Acheta domesticus* (European house cricket), specifically focusing on resource prioritization between mating and food preferences. Utilizing approximately 50 mature and 50 juvenile crickets, the experiment involved filter papers scented with female pheromones and dog food to represent mating and food resources. While mature males showed a slight preference for female cues, the difference was not statistically significant with a 95% confidence level. In contrast, juvenile crickets exhibited a significant preference for female scents over food scents. Additionally, Mann-Whitney U-tests revealed no significant differences between the two groups in the time spent on either filter paper. This study contributes to understanding resource prioritization in house crickets, suggesting that, in the given conditions, both juvenile and mature males prioritize mating cues over food cues. However, the lack of significant differences between the groups raises questions about potential changes in preferences with maturity. The study concludes by proposing avenues for further research, including increasing sample sizes, exploring different food types, and considering hunger levels as a potential variable influencing resource prioritization in crickets.

I. Introduction

Acheta domesticus, commonly known as the European house cricket, has experienced a surge in population over recent decades due to the growing pet trade and the use of crickets as a standard food source for various animals.[1] Despite its name, this cricket species (measuring approximately 16 to 21 millimeters) is primarily native to Southeast Asian countries like China and Japan; however, the species has managed to spread globally, largely facilitated by human activities.[2] House crickets exhibit a yellowish coloration and possess three main body segments: abdomen, thorax, and head, consistent with other insects in the class Insecta. Notably, these crickets deviate by adapting both fore and hind wings.[3] To distinguish between males and females, note that females feature a distinctive structure called the ovipositor, a tubular organ allowing for the deposition of eggs.[4] In their natural habitat, house crickets typically consume rotting leaves, fruit, vegetables, and other insects.[5] However, in laboratory settings, they can be nourished with nutritionally-dense gelatinous cubes and ground-up pet food.

Their varied diet and adaptability has contributed to the house crickets' success in different environments. The adaptation of fore and hind wings sets them apart from other insects, enabling them to cover more ground and explore diverse habitats.[67] Additionally, the unique ovipositor in females serves a crucial reproductive function, allowing female insects to lay their eggs in suitable locations for the subsequent development and survival of their

1. T. J. Walker and S. Masaki, "Natural History," in *Cricket Behavior and Neurobiology*, ed. F. Huber, T. E. Moore, and W. Loher (Cornell University Press, 1989).
2. Ibid.
3. T. J. Walker and T. E. Moore, "Singing Insects of North America (SINA)," 2003, https://sina.orthsoc.org/index.htm.
4. A. Haverkamp, B. S. Hansson, and M. Knaden, "Combinatorial Codes and Labeled Lines: How Insects Use Olfactory Cues to Find and Judge Food, Mates, and Oviposition Sites in Complex Environments," *Frontiers in Physiology 9* (2018): 49.
5. Walker and Moore, "Singing Insects."
6. R. D. Alexander and D. Otte, "Crickets," in *Encyclopedia of Insects*, ed. H. Vincent & T. Ring (Academic Press, 2009).
7. Walker and Moore, "Singing Insects."

offspring.[8] Understanding these morphological features provides insight into the evolutionary strategies that have allowed house crickets to thrive.

However, the prioritization of different resources and decision-making processes in insects–particularly crickets–remains an underexplored and often misunderstood area of research. Despite this gap, studies have been conducted to investigate whether animals, in general, exhibit a preference for finding resources over evading predation.[9][10][11] Notably, research has revealed that certain animals, such as *Rana catesbeiana* tadpoles, engage in riskier behaviors and actively search for food even in the presence of higher predation risks.[12] Decision-making patterns in house crickets are influenced by chemoreceptors located on their two front antennae.[13] These antennae serve multiple functions, with the most crucial being the gathering of information from various cues, including olfactory, gustatory, and mechanosensory inputs.[14]

When presented with food pheromones, house crickets are likely to actively seek and locate the source of the scent. Similarly, if males encounter female pheromones, they are expected to exhibit a similar seeking behavior. Existing studies suggest that olfactory cues play a significant role in guiding crickets toward potential mates.[15][16][17] This study aims to expand on these assumptions and investigate which scent holds the highest appeal, consequently influencing the associated fitness cost. Investigating the intricate interplay between sensory cues and decision-making processes in house crickets contributes to a deeper understanding of their behavior and reproductive strategies.

For this experiment, we delve into the decision-making and prioritization of different behaviors within a sample of *Acheta domesticus* house crickets. Specifically, our focus lies on exploring the choice between mating with a female and searching for food, attempting to discern whether juvenile and mature crickets exhibit a preference for one decision over the other. Drawing insights from previous research on animals like the fiddler crab (*Uca lactea*), which emphasizes the impact of food availability on reproductive decisions and mate-finding choices, we acknowledge the gaps in understanding how male crickets perceive the cost-benefit balance between finding a mate and securing food.[18]

The experimental methods employed in this study were adapted from previous research, that being a study on chemical-mediated predator avoidance in the European house cricket conducted by CD Hoefler, utilizing filter paper, pheromones, and decision-making paradigms.[19]

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8. Alexander and Otte, "Crickets."
9. C. D. Hoefler, L. C. Durso, and K. D. McIntyre, "Chemical-mediated Predator Avoidance in the European House Cricket (*Acheta domesticus*) is Modulated by Predator Diet," *Ethology* 118, no. 5 (2012).
10. A. Sih, "Optimal Behavior: Can Foragers Balance Two Conflicting Demands?" *Science* 210, no. 4473 (1980).
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13. V. D. Shields, C. E. Weaver, and S. Farmer, "Functional Morphology of Sensory Organs of the House Cricket, *Acheta domesticus* (L.): A Morphological and Physiological Investigation," *The FASEB Journal* 36, no. 1 (2022).
14. Ibid.
15. B. A. Assis, C. Trietsch, and M. W. Foellmer, "Male Mate Choice Based on Chemical Cues in the Cricket *Acheta domesticus* (Orthoptera: Gryllidae)," *Ecological Entomology* 42, no. 1 (2017).
16. Tad N. Hardy and Kenneth C. Shaw, "The Role of Chemoreception in Sex Recognition by Male crickets: *Acheta domesticus* and *Teleogryllus oceanicus*," *Physiological Entomology* 8, no. 2 (1983).
17. D. Otte and W. Cade, "On the Role of Olfaction in Sexual and Interspecies Recognition in Crickets (*Acheta* and *Gryllus*)," *Animal Behaviour* 24, no. 1 (1976).
18. T. W. Kim et al., "To Court or Not to Court: Reproductive Decisions by Male Fiddler Crabs in Response to Fluctuating Food Availability," *Behavioral Ecology and Sociobiology* 62, no. 7 (2008).
19. Hoefler, Durso, and McIntyre, "Chemical-mediated Predator Avoidance."

The outcomes of this experiment aim to contribute to the general understanding of house crickets and, more broadly, invertebrate behavioral decision-making when faced with potential resources. In our hypothesis, we anticipate a statistically significant difference in the mating decisions and preferences of two treatment groups: juvenile and adult males. We predict that adult males will exhibit a preference for female cues, spending more time on female-scented filter paper, while juveniles are expected to allocate their time more evenly across the different filter paper types. This will potentially suggest that mature males are more interested in mating and juvenile crickets are more concerned with food and development.

II. Material and Methods

The materials needed to conduct this study are as follows: approximately 50 individual mature and 50 individual juvenile *Acheta domesticus* house crickets obtained from a local pet store, a total of 80 11 cm Nerd Lab filter papers, half a kilogram of ground-up dog kibble, metal tweezers, three stopwatches, 80 cotton balls, and over 100 five-ounce plastic deli cups and their respective lids. In order to house the almost 100 or so individuals, crickets were first kept in two separate two-gallon plastic containers, with plenty of dog food and multiple cardboard egg cartons. The crickets were separated into mature adults and young juvenile instars. However, approximately 24 to 48 hours prior to trials, male crickets were isolated within the five-ounce plastic deli cups, with about 15 grams of ground dog food and a damp cotton ball allocated to each of the temporary living spaces. This differentiation between the sexes was done using the same method previously stated, with females having a unique ovipositor structure between their back two hind legs. The reason males needed to be separated from the rest of the population was to cleanse their olfactory receptors completely of any female pheromones within the larger cage.

As males were placed into their isolated plastic containers, females were also placed into 2.5-gallon clear plastic containers lined with eight filter papers. Around 16 individual females were added to each of the containers in order to have an average ratio of two females per filter paper and ensure enough pheromones were transferred onto the paper. Once these respective amounts of female-scented filter papers were set up, the same technique was used for dog-food-scented filter paper: eight or so filter papers were added to a 2.5-gallon clear plastic container and then covered with dog food. Both the filter papers were left for approximately 24 hours in order to maximize the olfactory cues present on each of them and ensure that male receptors could not potentially miss either of the scents. The next day, the filter papers were removed from each of the boxes using latex gloves and then placed into separate containers until further use.

Prior to trials, males were labeled (#1 through #20 for mature adults and J1 through J20 for juveniles) and given to one of the three technicians. The technicians then placed the male into a four-gallon plastic tank with a five-ounce deli cup on top of it. The technicians would move the cup to the center of the tank and add in the two types of filter papers, dog-food-scented and females-scented, into the opposing sides of the tank. Once ready, technicians removed the cup holding the male cricket in place and began a timer for five minutes. The technicians then recorded the time spent on each of the filter papers using a separate stopwatch. After the five minutes were completed, each of the times were calculated and recorded in two separate tables: one for mature adult males and one for juveniles. The males were then removed from the tank using tweezers and placed back into their respective deli cups. At this point, males were placed into the freezer for the potential of measuring the body length and determining age and/or maturity. These steps were then repeated with new filter paper and new males until all 40 total trials were completed.

Once all of the trials were completed, a data analysis and statistical tests were run on the results in order to draw any suggestive conclusions. Averages and standard deviations were first calculated for all four of the different groups: female-scented filter paper for mature adults, food-scented filter paper for mature adults, female-scented filter paper for juveniles, and food-scented filter paper for juveniles. This information was then put into a visual representation as seen in Figure 1. Then, two separate significant tests were performed on each set of data. First was a one-tailed T-test assuming equal variance, run in order to compare the preference for females versus food by mature adult males. The second was another one-tailed T-test assuming equal variance, but this time run to determine the preference for females versus food by juvenile crickets. Finally, two more statistical tests were performed in order to compare the differences in the preferences of adults versus juveniles. This consisted of a two-tailed Mann-Whitney U-test run on the time spent on the female-scented filter

paper between both groups of crickets, and another run on the time spent on dog food-scented filter paper. All of these significant tests will hopefully give some insight into the preferences and statistical differences between juvenile male crickets and mature adult male crickets.

Table 1: Experimental Design

Hypothesis	Crickets will exhibit a statistically different preference for females versus food between the two treatment groups of juvenile and mature male adults.
Prediction	Mature male adults will spend more time on the female-scented filter paper than the juveniles, while juveniles will have around equal time spent on each of the filter paper types.
Variables	
Independent	Maturity of the cricket (adult or juvenile)
Dependent	Time spent on each of the respective filter papers (seconds)
Standardized	Size of filter paper, Time soaked in pheromones, Starting point, Time limit, Freshness of filter paper, Brand of filter paper, Size of container, Species of organism, Time of day
Components of Procedure	
Levels of Treatment	2
Replications	1
Sample Size	n = 40
Control Treatment	None

III. Results

Overall, a statistical analysis revealed no significant difference in mature adult male crickets' preference. In contrast, juveniles exhibited a significant preference for female pheromones over dog food pheromones. Mann Whitney U-tests confirmed no significant differences between adult males and juveniles in their responses to both papers.

The first t-test was conducted on the data collected from the mature male adult trials of 40 males who underwent the experiment. There was no statistically significant difference between the male preference for the female-scented filter paper, with an average time spent on the filter paper being (36.1±43.2) seconds, and the dog-food-scented filter paper, which has an average length traveled on the line at (58.6±43.5) seconds, with a p-value of 0.05449. The data analysis of mature adult males' data gave a t-calculated value of -1.641 at 48 degrees of freedom, meaning the t-calculated is smaller than the t-critical of 1.686. This p-value, slightly greater than 0.05, suggests that the adult male crickets almost show a preference in the scent (Figure 1).

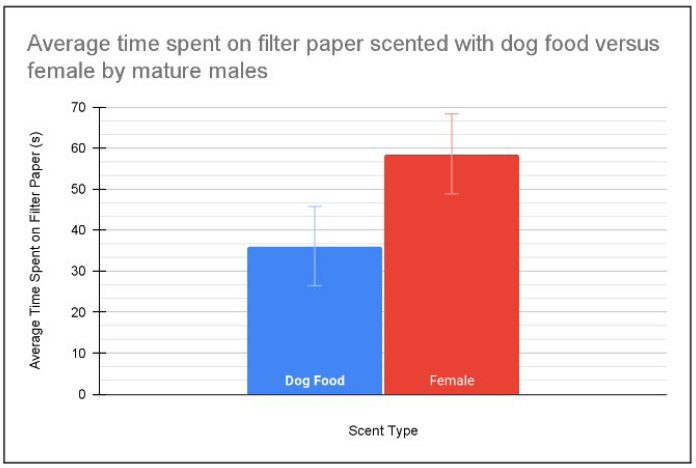

Figure 1. The graph shows the results of data from the mature adult male trials. The average time spent on a specific scented filter paper (in seconds) by mature adult males in regards to dog food and female scents. The results show there is no statistically significant difference in preference for dog-food-scented filter paper (μ=36.1±43.2 s; SE = 9.65) over the female-scented filter paper (μ=58.6±43.5 s; SE = 9.73), p = 0.05449.

The second t-test was performed on the data collected from the juvenile trials. This t-test suggests that there is, in fact, a significant difference between the juveniles' preferences for the female scent over dog food scent. The results gave a mean of (19.2±14.5) seconds for time spent on the dog-food-scented filter paper, and a mean of (19.2±14.5) seconds for time spent on the female-scented filter paper, with a p-value of 0.001064. This supports the conclusion that crickets do show a preference for female pheromones over food scents (Figure 2).

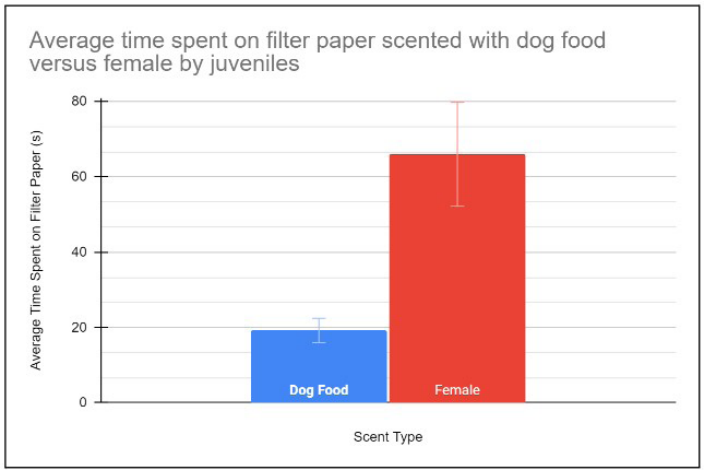

Figure 2. The graph shows the results of data from the juvenile trials. The average time spent on a specific scented filter paper (in seconds) by juvenile instar crickets in regards to dog food and female scents. The results show there is a statistically significant difference in preference for female-scented filter paper (μ=66.0±61.8 s; SE = 13.82) over the dog-food-scented filter paper (μ=19.2±14.5 s; SE = 3.24), p = 0.001062.

The third and fourth significant tests performed on the data were two-tailed Mann-Whitney U-tests. The first was a Mann-Whitney U-test comparing the data collected from the adult males and juveniles on how much time each of them spent on the food-scented filter paper. The test suggested that there was no significant difference between the two treatments, or groups of crickets, with a p-value of 0.14706. The second Mann-Whitney U-test tested the difference between the adult males and juveniles and the times they spent on the female-scented filter paper. This test also found no statistically significant difference between the adult males and the juveniles with a p-value of 1.

IV. Discussion

Similar to the findings of previous studies, almost all animals have preferences in terms of resources and where they prioritize them in terms of cost-effective activities, and crickets are no different.[20][21][22] From the data and results found in this study, it seems as if male crickets have a preference for female pheromones over the scents of food, specifically ground-up dog kibble. This is because, in the juvenile trials, there was a statistically significant difference between time spent on the filter paper coated in female cricket scent and the filter paper covered in the scent of dog food, specifically in favor of the female scent (Figure 2). While the mature adult male trials technically did not have a significant difference in preference for the scents at a 95% confidence level, they just barely missed the threshold. To explain, the p-value of 0.05449 means that it can be said only with a 94.5% confidence that the results were not random and that the mature adult males did in fact have preferences (Figure 1). This highlights that in both the juveniles and mature adult house crickets, there is a statistical tendency to choose females over food in this scenario. However, this data is extremely limited and specific, as the results could be drastically different if males were fed less, fed a different or potentially more appealing food, or if there was a visual cue in addition to the olfactory ones.

The other statistical tests performed were Mann-Whitney U-tests between the two treatments and groups. These tests are able to determine whether there is a difference in the times spent on each of the same filter papers between the groups. For the dog food-scented filter paper, the test resulted in a U-value of 146, which is larger than the U-critical of 127. This means that there is no significant difference between the time spent on the dog-food-scented filter paper between juveniles and adult males: specifically a p-value of 0.14706, which is greater than 0.05 and therefore not significant. This means that juveniles and adults spend relatively similar amounts of time on the food-scented filter paper. Furthermore, in the second Mann-Whitney U-test comparing the times spent on the female-scented filter paper between juveniles and adult males, there was a very large U-value of 199.5, which resulted in a p-value of 1. This p-value means that the times spent on the female filter papers are extremely similar, if not almost identical, between juveniles and adult males. This all suggests that there is no statistically significant difference in behavior between juveniles and adults, at least in resource prioritization between female pheromone cues and food cues. This is not too surprising with studies like

20. Hoefler, Durso, and McIntyre, "Chemical-mediated Predator Avoidance."
21. Sih, "Optimal Behavior."
22. Smith et al., "Feathering the Nest."

Dr. Elizabeth Swanger's, in which she studied how sexual choices in adulthood of crickets can be affected by sexual signals in adolescence, suggesting juveniles still detect females despite not being sexually mature.[23][24]

The hypothesis stated earlier suggested there would be a statistically significant preference for females versus food between the two treatment groups of juvenile and mature male adults. From the results just discussed, we can overall reject this hypothesis due to the lack of statistically significant differences between juveniles and adult males. That being said, part of the hypothesis does not need to be rejected since there was statistical evidence suggesting a difference in preference between the resources, specifically between the different treatment types – juvenile and adult – as well. This suggests that there is not a change in preferences that comes with maturity, and that male crickets will always prioritize females over food. This theory goes hand in hand with previous studies, in which animals have actually given up on their own fitness and survivability in order to potentially increase their reproductive success. The most extreme cases are cannibalism in praying mantises, where males will offer themselves as food for their mate and therefore offspring.[25] Overall, this will hopefully boost the success of their offspring, despite the male not being alive anymore. This is potentially a more low-cost example and could change with future research on this topic.

Should this experiment be repeated, one way in which one could have more conclusive and suggestive results is by increasing the sample size. The larger the sample size, the more accurate and precise the data will become. Having a smaller sample size, such as 20 trials per treatment, allows for outliers to skew the data and potentially give false averages and results that are not true. The biggest and probably most dramatic change would be to increase the trials to about 100 per treatment, in order to have enough data to potentially outweigh the outliers and therefore have accurate results. Another way in which this experiment could be improved or adapted for future research is with the types of food. There may be a preference for female scent over food not because male crickets truly prefer females over food, but rather because they have a greater distaste for dog food. A way in which this hypothesis could be tested is by using different foods on the filter paper and testing for preferences between them. This could potentially suggest that males prefer foods more often found in nature, such as decaying fruits or other insects, than the dog food provided in this experiment. Another way in which this experiment can be advanced is by changing the hunger of the males. While it is seen that males prefer females over food in this experiment, these preferences could potentially switch in a less nutrition-rich environment. This relates to the experiment conducted by DT Gwynne, who found that in environments with low amounts of food, male Mormon crickets become much more selective and do not spend as much time on females.[26] Overall, there is much more to research on resource prioritization and, more specifically, on decision-making behaviors within European House Cricket, *Acheta domesticus*.

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23. E. Swanger and M. Zuk, "Cricket Responses to Sexual Signals are Influenced More by Adult Than Juvenile Experiences," *Journal of Insect Behavior* 28, no. 3 (2015).
24. A. E. Olvido, P. R. Fernandes, and T. A. Mousseau, "Relative Effects of Juvenile and Adult Environmental Factors on Mate Attraction and Recognition in the Cricket, *Allonemobius socius*," *Journal of Insect Science* 10, no. 1: 90 (2010).
25. T. R. Birkhead, K. E. Lee, and P. Young, "Sexual Cannibalism in the Praying Mantis Hierodula membranacea," *Behaviour* 106, no. 1-2 (1988).
26. D. T. Gwynne, "Food Quality Controls Sexual Selection in Mormon Crickets by Altering Male Mating Investment," *Ecology* 74, no. 5 (1993).

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